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1. Title of the invention: MULTI-WAY LOUDSPEAKER SYSTEM
2. Invention amount described in the [Field of Patent Claims]: 2
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6. Contents of documents:
(1) Specifications 1
(2) Drawings 1
(3) Application form 1
(4) Mandate 1

SPECIFICATIONS

1. Title of the invention:

Multi-Way Loudspeaker System

2. Field of Patent Claims:

(1) A multi-way loudspeaker system provides a low/high sound distribution circuit for distributing an audio signal to a variety of prescribed areas, and a low/high sound speaker which is respectively driven by the audio signal obtained by the above-mentioned low/high sound distribution circuit. A multi-way loudspeaker system connects the above-mentioned high sound speaker corresponding to polarity of the above-mentioned low sound speaker so as to perform an opposite polarity, arranges the above-mentioned high sound speaker into the next part after the above-mentioned low sound speaker, and forms a sound pressure frequency characteristic of sound generated by the said low/high sound speakers and a phase frequency characteristic to be even.

(2) In accordance with [Claim 1], a multi-way loudspeaker system inserts a phase delay circuit into a previous part or next part of the above-mentioned high sound distribution circuit.

3. Detailed Explanation of the Invention

The present invention relates to a multi-way loudspeaker system, purpose of which is to improve a waveform transmission characteristic by constituting a sound pressure frequency characteristic and phase frequency characteristic to be even.

At the prior multi-way loudspeaker system, the speakers were arranged at the same plane, and K type filter was frequently used as a distribution circuit.

Also, a polarity of case when a speaker is connected to a distribution circuit, was not rarely determined by a try mistake. At such prior multi-way loudspeaker system, even if a sound pressure frequency characteristic is almost even, a phase frequency characteristic was ignored, therefore, there was no evenness due to reason that phase rotation occurs or the like and a waveform transmission characteristic was extremely bad. However, at only a distribution circuit an evenness of frequency characteristic of both width and phase was also presented, but a phase characteristic of speaker was still ignored, therefore, frequency characteristics of both sound pressure and phase of the whole loudspeaker system could not be even.

To solve the above-mentioned problems of the prior art, the present invention provides speaker system which uses a remarkable waveform transmission characteristic by making both sound pressure and phase frequency characteristic even, putting a transmission time of sound from phase of speaker and speaker till microphone under consideration.

The preferred embodiment of the present invention will be explained further below.

First of all, a phase characteristic of speaker will be described. The characteristic of sound wave radiated from the speaker can be expressed by a transmission function used a minimal phase characteristic and time delay occurred due to transmission of sound wave. The phase characteristic of the speaker is measured as standard of output of delay device which compensates the above-mentioned time delay, therefore, if phase of the speaker changes, an apparent phase characteristic cab be changed. The present invention performs a plan of speaker system, using it.

Namely, the present invention makes a combination of two speakers as a base as shown by solid line of FIGURE 1. An audio signal supplied to an input terminal 1 is added to a low sound speaker 4 through a low sound distribution circuit 3, and then is added to a high sound speaker 7 through a high sound distribution circuit 6 and a phase delay circuit 5. Then, a sound radiated from each speaker 4, 7 is counted by a microphone 2. However, the phase delay circuit 5 is not required.

First of all, the case when the phase delay circuit 5 is not used will be described further below. Filters of 6 dB/oct, 12 dB/oct and 1 SdB/oct are respectively used as the high sound distribution circuit 6 and the low sound distribution circuit 3, a polarity of the high sound speaker 7 is connected oppositely to the low sound speaker 4, as shown in FIGURE 1. An amplitude phase characteristic of this state is shown in FIGURE 3 (a). An amplitude characteristic of sound radiated from the low sound speaker 4 is indicated by solid line 14 and a phase characteristic is indicated by solid line 15; an amplitude characteristic of sound radiated from the high sound speaker 7 is indicated by solid line 16 and a phase characteristic is indicated by solid line 17. Thus, if the low sound speaker 4 can come nearer to phase of the microphone 2, in comparison with a phase of the high sound speaker 7 as shown in FIGURE 2, a phase of sound radiated from the low sound speaker 4 can be promoted. This phase is indicated by broken line 18 of FIGURE 3 (a). If the above-mentioned operation is performed, the phase frequency characteristic can be even within area where two speakers are received. Namely, an amplitude characteristic combined two speakers 4, 7 is shown by solid line 19 of FIGURE 3 (b), a phase characteristic is respectively shown by solid line 20, the

phase is not rotated, and it becomes an extremely even characteristic.

When the phase characteristic of high area is not even enough by the above-mentioned operation, the phase delay circuit is used. Namely, at the speaker system such as that shown in FIGURE 4 (a) and at which the amplitude characteristic is shown by 21 and phase characteristic is shown by 22, an audio signal is supplied through the circuit which has the phase delay characteristic such as that shown in FIGURE 4 (b). Thus, a whole area passing circuit and a low area passing circuit are used as the phase delay circuit 5. An amplitude characteristic of the whole area passing circuit is shown by solid line 23 of FIGURE 4 (b), an amplitude characteristic of the low area passing circuit is shown by broken line 24 of FIGURE 4 (b), and phase characteristic of both circuits is shown by solid line 25 of FIGURE 4 (b). If electric signal is supplied through the phase delay circuit 5 which has such characteristics, the characteristics of the whole speaker system are that shown in FIGURE 4 (c). Namely, the amplitude characteristic 26 doesn't almost differ from the amplitude 21 of FIGURE 4 (a), but the phase characteristic is improved as shown by solid line 28, comparing with phase characteristic (broken line 27 of FIGURE 4 (c)) of case when the phase delay circuit 5 is not used.

Then, a concrete circuit constitution of the whole area passing circuit used as the above-mentioned phase delay circuit 5 will be explained further below.

(1) The whole area passing circuit

It consists of circuits such as that shown in FIGURE 5 (a), (b) and (c). Thus, (a), (b) and (c) of FIGURE 5 are equal by principle of divide equally in 2 the Bartlett, therefore, the circuit shown in FIGURE 5 (a) will be explained further below. This circuit is secondary whole area passing circuit, amplitude is 1

instead of whole zone, 360° delay of only phase occurs at a high area. A shadow phase extent ß of this circuit is expressed by the next formula.

$$\beta = 2\tan^{-1}\frac{\omega L_a}{R(1-\omega^2 L_a C_a)} \quad \cdots\cdots (1)$$

However, ? is an angular frequency, R, La, Ca are resistances respectively shown in FIGURE 5, and there are value of inductance and condenser.
As understandable from formula (1), this circuit is

$$\omega_o = \frac{1}{L_a C_a} = \frac{1}{L_b C_b} \quad \cdots\cdots (2)$$

It has 180° phase delay at angular frequency ? , and its delay characteristic is

$$m = \frac{L_b}{L_a} = \frac{C_a}{C_b}$$

It can be changed by parameter m. Consequently, a phase can be controlled by changing this parameter m.

(2) The low area passing circuit

It consists of circuits such as that shown in FIGURE 6. Then, if an interrupted frequency used by this circuit is selected with a high frequency than a high area limited frequency of used speaker, it can be used as a phase delay circuit.

At last, the method for forming a multi-way loudspeaker system of the present invention will be described further below using all the above-mentioned principles.

1. The case when 2-ways loudspeaker system is formed

In this case, the method explained by FIGURE 1 and FIGURE 2 can be used as it was.

Namely, a polarity of the high sound speaker 7 is connected oppositely to a polarity of the low sound speaker 4 as shown in FIGURE 1, and the high sound speaker 7 can be arranged at the other side than the low sound speaker 4 is arranged, as shown in FIGURE 2.

2. The case when 3 or more ways loudspeaker system is formed

In this case also, it can be formed similarly to that of case of 2-ways loudspeaker system, but a distribution circuit, speaker and phase delay circuit are added. Namely, the phase delay circuit 8, distribution circuit 9 and speaker 10 are added as shown in FIGURE 1. In this case also, a polarity of the speaker 10 is connected oppositely to a polarity of the low sound speaker 4, and the speaker 10 is arranged at the other side than the speaker 7 is arranged, as shown in FIGURE 2. Then, the amplitude characteristic of the speaker 10 of that time is indicated by broken line 29 of FIGURE 3 (a), and the phase characteristic is indicated by the broken line 30. Also, the amplitude characteristic of the whole speaker system of this case is indicated by the broken line 31 of FIGURE 3 (b), the phase characteristic is indicated by the broken line 22. Namely, an interrupted frequency of the distributed circuit 9 is correctly selected, and in case of 3-ways loudspeaker system also, the both amplitude frequency characteristic and the phase frequency characteristic can be even as shown in FIGURE 3 (b).

As mentioned above, in accordance with the present invention, the both sound pressure frequency characteristic and phase frequency characteristic can be even, by properly arranging a characteristic of network consisted of distribution circuit and phase delay circuit, considering a connection and arrangement of each speaker, therefore, a waveform transmission characteristic of the whole speaker system can be improved.

4. Brief description of the drawings

FIGURE 1 is a block diagram showing a multi-way loudspeaker system of the preferred embodiment of the present invention;

FIGURE 2 is a side view for explaining of phase relation of the speaker;

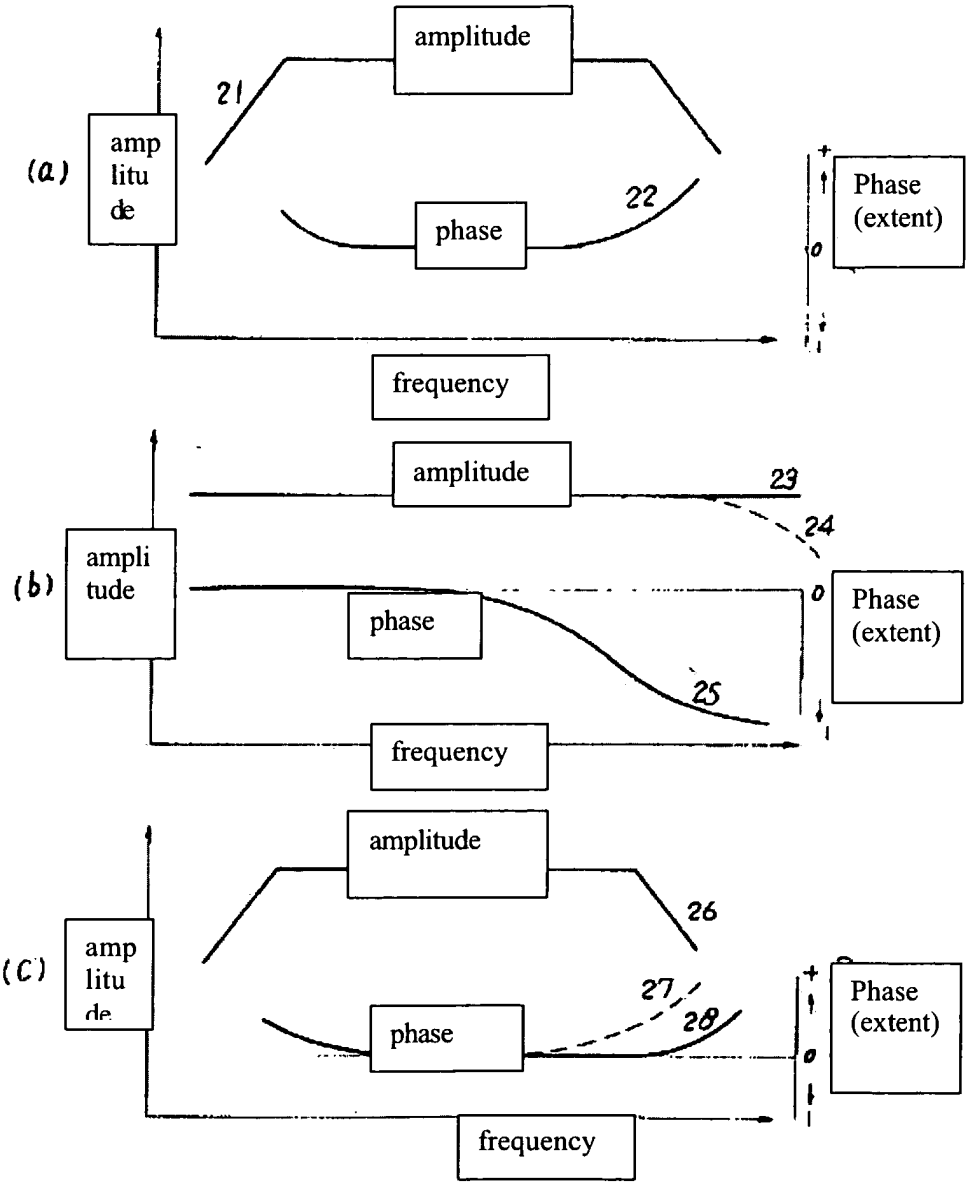
FIGURE 3 and FIGURE 4 are diagrams showing frequency characteristics for explaining the operation;

FIGURE 5 (a), (b), (c) and FIGURE 6 are circuitry diagrams showing the phase delay circuit used in the above-mentioned preferred embodiment.

[Description of Numbers]

1 is input terminal;
2 is a microphone;
3 is a low sound distribution circuit;
4 is a low sound speaker;
5, 8 are phase delay circuits;
6, 9 are high sound distribution circuits;
7, 10 are high sound speakers.

第 4 図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Phase (extent)
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(C)
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26
27
28
phase
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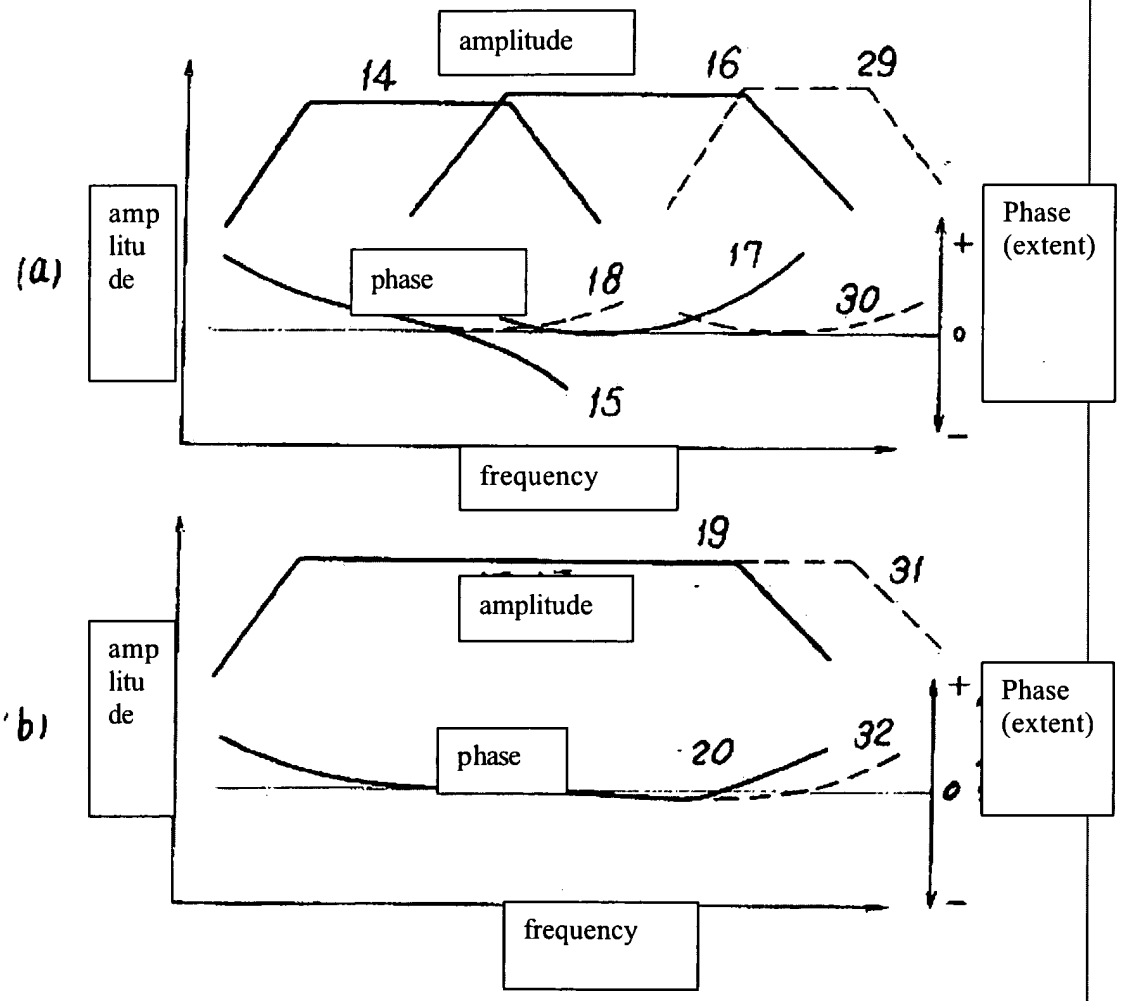
Phase (extent)
frequency

第 3 図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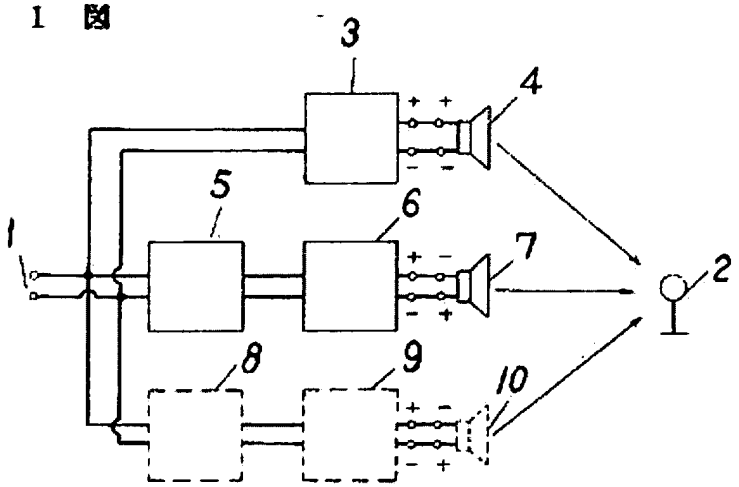
第 1 図



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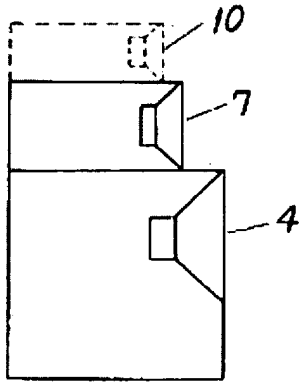
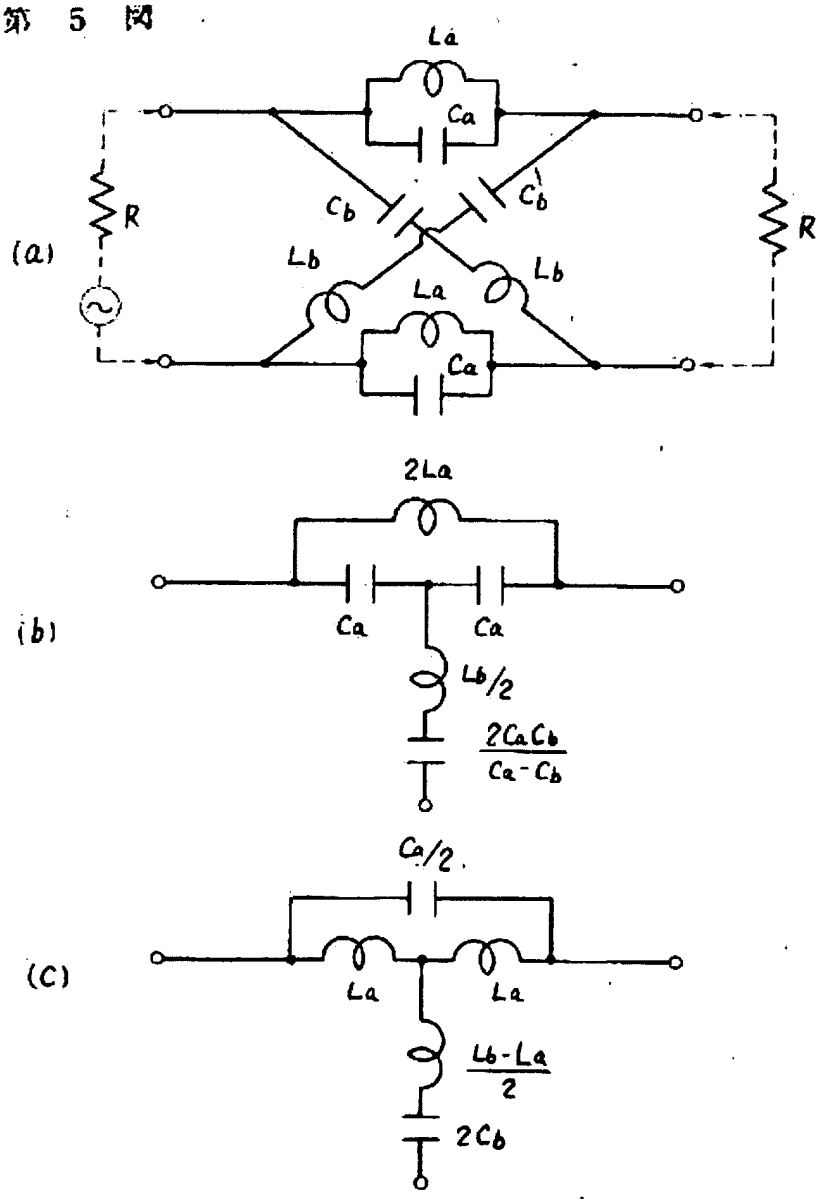


第 5 図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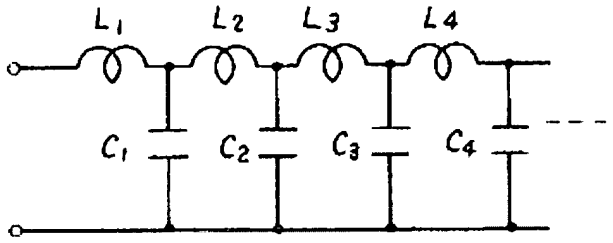
(C)
Ca/2
La
La
Lb-La / 2
2Cb

第 6 図



Formalities

1. Expression of Event
Patent Application number 109686 of 1975 year
2. Title of the Invention
Multi-way Loudspeaker System
3. Corrector
MATSUSHITA ELECTRIC IND CO LTD
4. Agent: patent attorney:
5. Object of Correction
A part of concrete explanation of the Invention of Specifications
6. Content of correction

$$\lceil\ \omega_0 = \frac{1}{L_a C_a} = \frac{1}{L_b C_b} \qquad \cdots\cdots\cdots (2)\ \rfloor$$

is corrected into

$$\lceil\ \omega_0 = \frac{1}{\sqrt{L_a C_a}} = \frac{1}{\sqrt{L_b C_b}} \qquad \cdots\cdots\cdots (2)\ \rfloor$$

$$\lceil\ m = \frac{L_b}{L_a} = \frac{C_a}{C_b}\ \rfloor$$

is corrected into

$$\lceil\ m = \sqrt{\frac{L_b}{L_a}} = \sqrt{\frac{C_a}{C_b}}\ \rfloor$$